Crucible Furnace

2005-06-18

Taking some inspiration from Lionel Oliver's "2 bucks" furnace I purchased two 15 litre galvanised steel buckets from BigW. A bit of careful work with a jig saw, hole saw and electric drill produced all the required holes in the buckets and some 10-ply card stock was rolled into the bore and tuyere form work. The transition section between the tuyere and the bore was calculated graphically on paper and transferred to the tuyere form which was then cut to profile and neatened up with scissors to make a good fit. Some self-tappers were driven in around the circumference at the top of the bucket to provide some reinforcement and anchoring into the refractory material.

The refractory mix was identical to the trial furnace. For this initial crucible furnace I felt it was safer to stick with a known-usable recipe rather than something experimental. My reasoning was that at the very least this material should be usable for conducting tests on experimental refractory bricks at a later date - if the bricks survived and the furnace walls didn't then I'd have something better to rebuild the furnace with.

The cardboard form work for the bore proved too fragile during ramming of the refractory. It bulged and tore, so I had to form the bore by hand. The inner surface did eventually turn out OK, after much swearing and manual manipulation with a trowel. Next time I'll back it up with a rigid material, like a tin can or a PVC water pipe.

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Only the bottom half of the furnace was completed in the first sitting. It required a bit more refractory than I had calculated and it was getting too late to start on the top half in the same evening. Fortunately the bottom half was sufficiently deep to use with the available crucibles by just placing some firebricks across the top to keep some of the heat in but still vent gasses. It was decided to put off building the top indefinitely and just use the bottom.

The refractory was allowed to cure for four days, then dried in the kitchen oven. It was a tight fit, with the various pieces of furniture (plinth, plugs, etc) being placed around and on top of the furnace bucket. The temperature was taken to 120 C and held there for 3 hours, then raised to over 400 C and held for six hours to completely dry the refractory. The old kitchen stove has thermostat issues and its "full blast" setting (> 500 F) rarely turns off the element, the heat could be felt soaking through the wall behind the oven. The oven was then cooled slowly over 8 hours back to room temperature.

The initial burn occurred some days after the drying. I was concerned that it may have soaked up some moisture in the meantime, so I fired it quite gently at first. After 30 minutes I was feeling confident enough to crank up the burner from its idle point to 100 kPa and put in some metal.

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A cast iron "prawn/shrimp pot" was used as a primitive crucible. Recent renovations at my place had left a huge pile of scrap Aluminium extrusion sections, all powdered coated a greenish-grey colour. This metal seemed just the ticket to test the furnace with, a short length was picked, all the screws and wall plugs removed and stood up in the crucible. Within a few moments the powder coat binder burnt off with a smoky orange flame and that "burning plastic" smell. The Aluminium softened and flowed into the crucible. Several more lengths went in, all melting down nicely.

I'd be exaggerating if I said I had prepared suitable skimming tools and tongs. I did actually purchase some stainless utensils (large serving spoons, etc) for this purpose but left them upstairs for this initial run. The metal was allowed to cool in the crucible and then dumped out. Obviously this left the ingots quite drossy, but at least it proved the furnace worked.

A tin can was also tried as a crucible. It survived only one melt before I punched out the bottom accidentally while it was hot, but it did prove usable as a throw-away crucible. The cast iron pot crucible scaled somewhat, but appeared as though it would last quite a while in this kind of service.

The next day I prepared the crucible more carefully, with wire loops and a removable handle that allowed it to be extracted easily from the furnace. The ingots from the previous run were melted down again, skimmed and then the molten metal poured into a muffin pan to form ingots. Of course I had forgotten to burn off the coating on the muffin pan, so the Aluminium welded itself into the mold quite nicely. Bugger!

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I did however have a bread loaf tin for larger ingots so I carefully burnt it until it was covered in a nice oxide layer. As expected this worked a charm, casting a nice shiny ingot of Aluminium that just fell out once cool.

Having some success with the new furnace I tried using some Calcium Chloride as a flux. I cracked open a carton of "Damp Rid" and tossed in some of the prills. This worked quite well, allowing me to produce quite clean melts and sparkling ingots. I melted down all the dross from the previous melts with a large quantity of flux and recovered a surprising amount of metal from it. Calcium Chloride does have a fairly high melting point and isn't the best of fluxes, but I didn't have any KCl on hand to make a more traditional Soda/Mixed Salts flux.

Next I got fairly ambitious and wanted to see if I could melt down some Magnesium turnings. I did it in a closed crucible with some Calcium Chloride. I expected a disaster and wasn't disappointed. The turnings

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eventually ignited so I pulled it out of the furnace and tried to cool it by spraying water on the crucible alone. Of course some water got into the crucible and all hell broke loose. Steam and **Ammonia** fumes poured out and the lid rattled away. I didn't have much choice but to just blast the crucible with water mist until it cooled enough for the reaction to stop. Eventually the situation came under control and I could wash the mess out of the crucible. This is when I noticed a distinct smell of acetylene, on bringing the damn sludge near my ear I could hear the fizzing of the gas as it was liberated from the dark grey mess. I can only assume the Magnesium fire was hot enough to reduce the Calcium Chloride and react it with Carbon from the cutting fluid residue, forming Carbides! This interesting accident is something I'd like to investigate further.

A few more experiments were conducted, the last of which resulted in complete destruction of the cast iron crucible. Liquid cast iron completely missed the drain hole and channels in the bottom of the furnace and the burner flare partially filled up with metal. Bugger!

The flare was a write-off, but the burner pipe itself was unharmed despite leaving its thread marks in the cast iron the flare had ingested.

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The crucible side closest the burner completely melted and burnt out, while the rest of the crucible was reduced to largely black scale. Some liquid pooled in the bottom of the furnace too, welding itself to the vitrified refractory lining and had to be chipped out with a crowbar once cool.

Apart from the vitrification and some shrinkage cracks the furnace was unharmed despite operating for an extended period above 1200 C. It survived to melt more Aluminium over the following days (using a tin can,

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live to see many more melts. However I believe a reverberatory furnace would be a more practical device for melting down the remainder of the scrap Al, I intend to build a small test reverb furnace next and keep this crucible furnace for fairly small jobs.

2 comments.

Attachments

title	type	size
short video of melting Al	video/x-ms-wmv	962.174 kbytes

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